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Loison

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(54) **AUTONOMOUS ELECTRICITY PRODUCTION AND CONDITIONING SYSTEM FOR AN AIRCRAFT, ASSOCIATED AIRCRAFT AND METHOD**

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CPC ***B64D 13/06*** (2013.01); *B64D 2013/0644* (2013.01); ***B64D 41/00*** (2013.01); *Y02E 20/14* (2013.01); *B64D 2241/00* (2013.01); *Y02T 50/44* (2013.01); *Y02T 50/56* (2013.01)
USPC .... **244/58**; 244/53 A

(58) **Field of Classification Search**
USPC .... 244/58, 53 A
See application file for complete search history.

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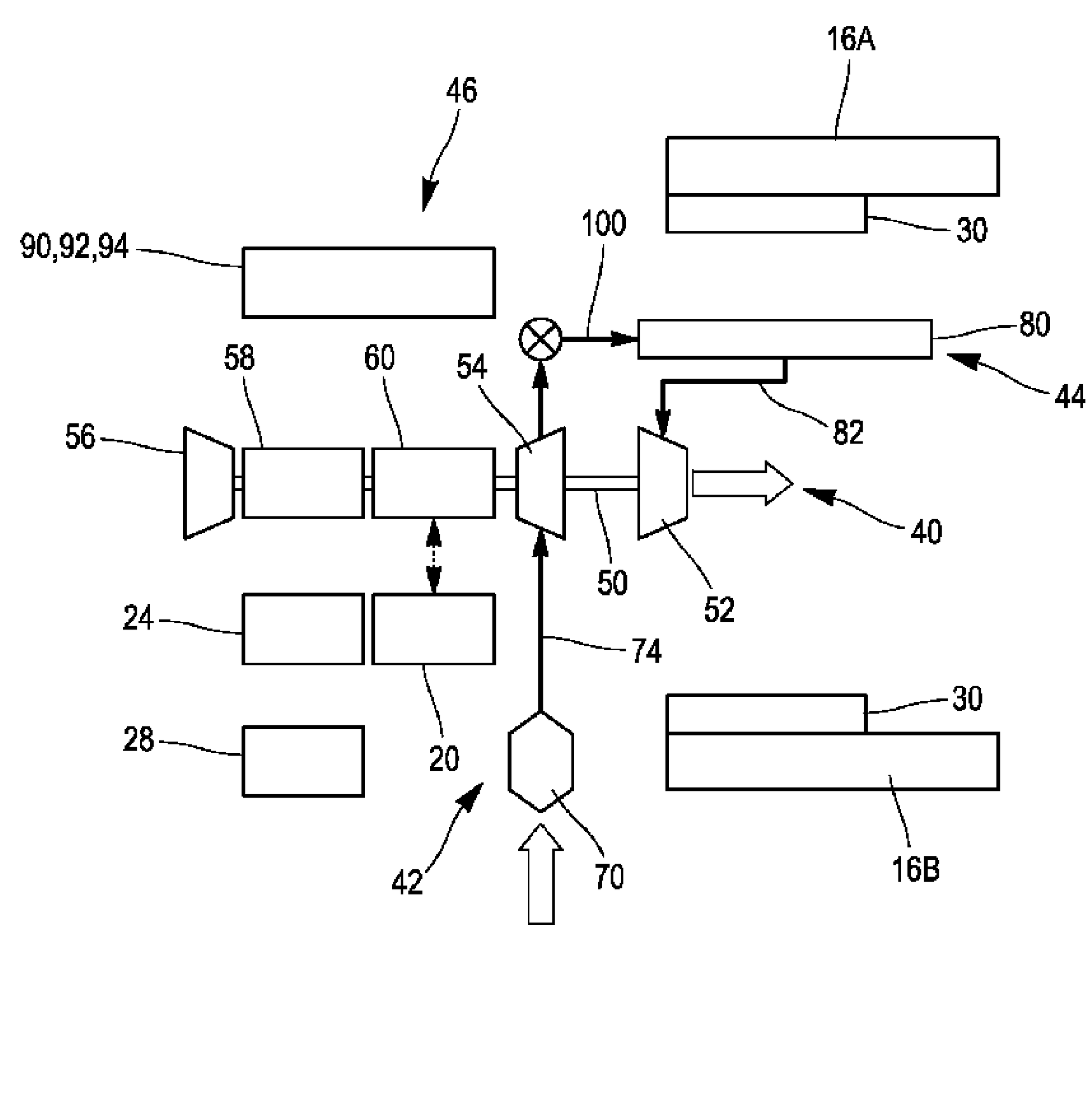
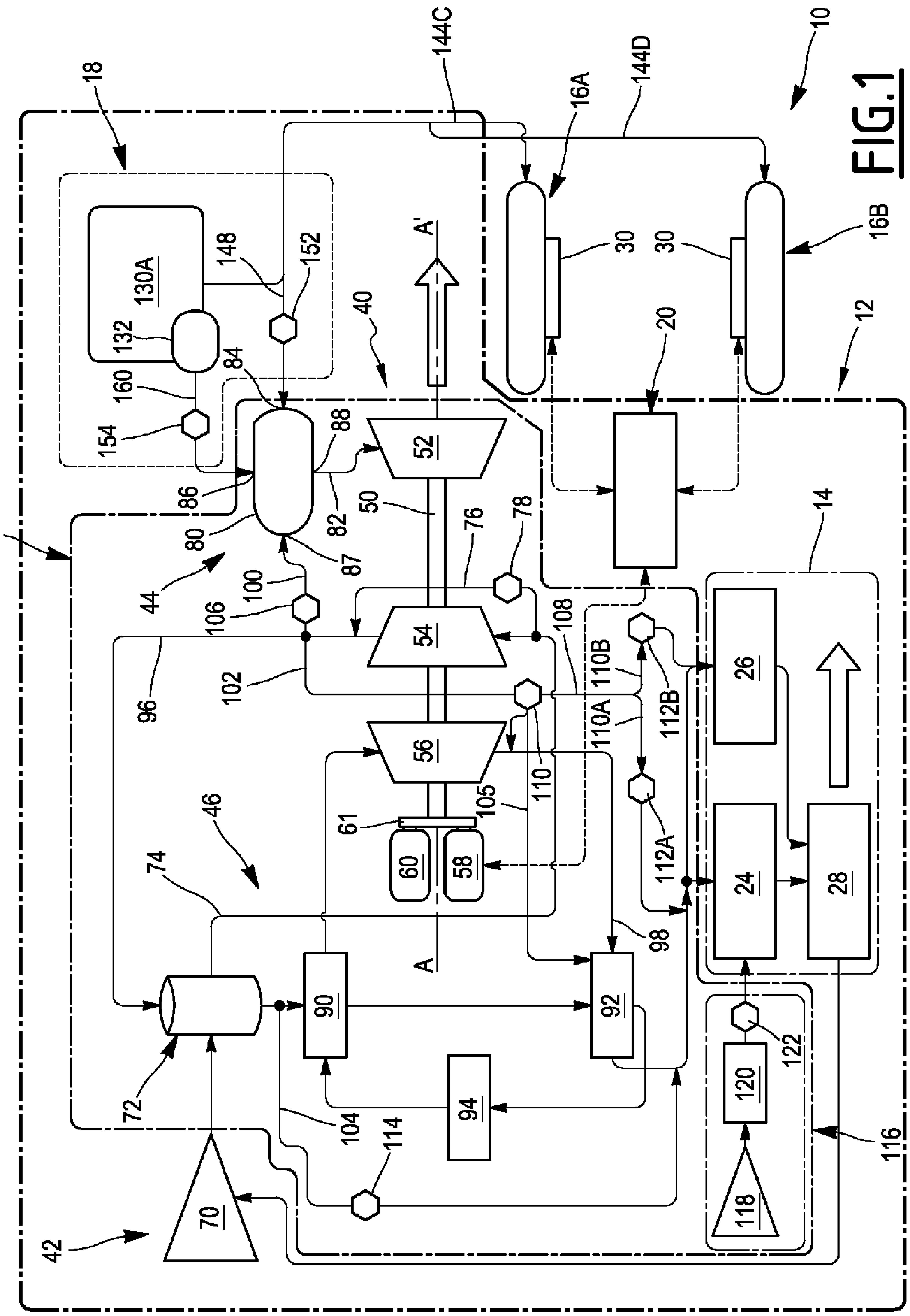
(57) **ABSTRACT**

An environmental control system including an upstream assembly supplying outside air to a rotary system of an aircraft, the air not having passed through a propulsion engine of the aircraft, and wherein the rotary system includes a rotary shaft, a power turbine, a compressor and a cold turbine, and wherein the upstream supply assembly is connected to an inlet of the compressor mounted with the rotary shaft that is rotated by the power turbine and wherein the shaft is supplied with compressed gas from the compressor toward the cold turbine.

16 Claims, 10 Drawing Sheets

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110A
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FIG. 1

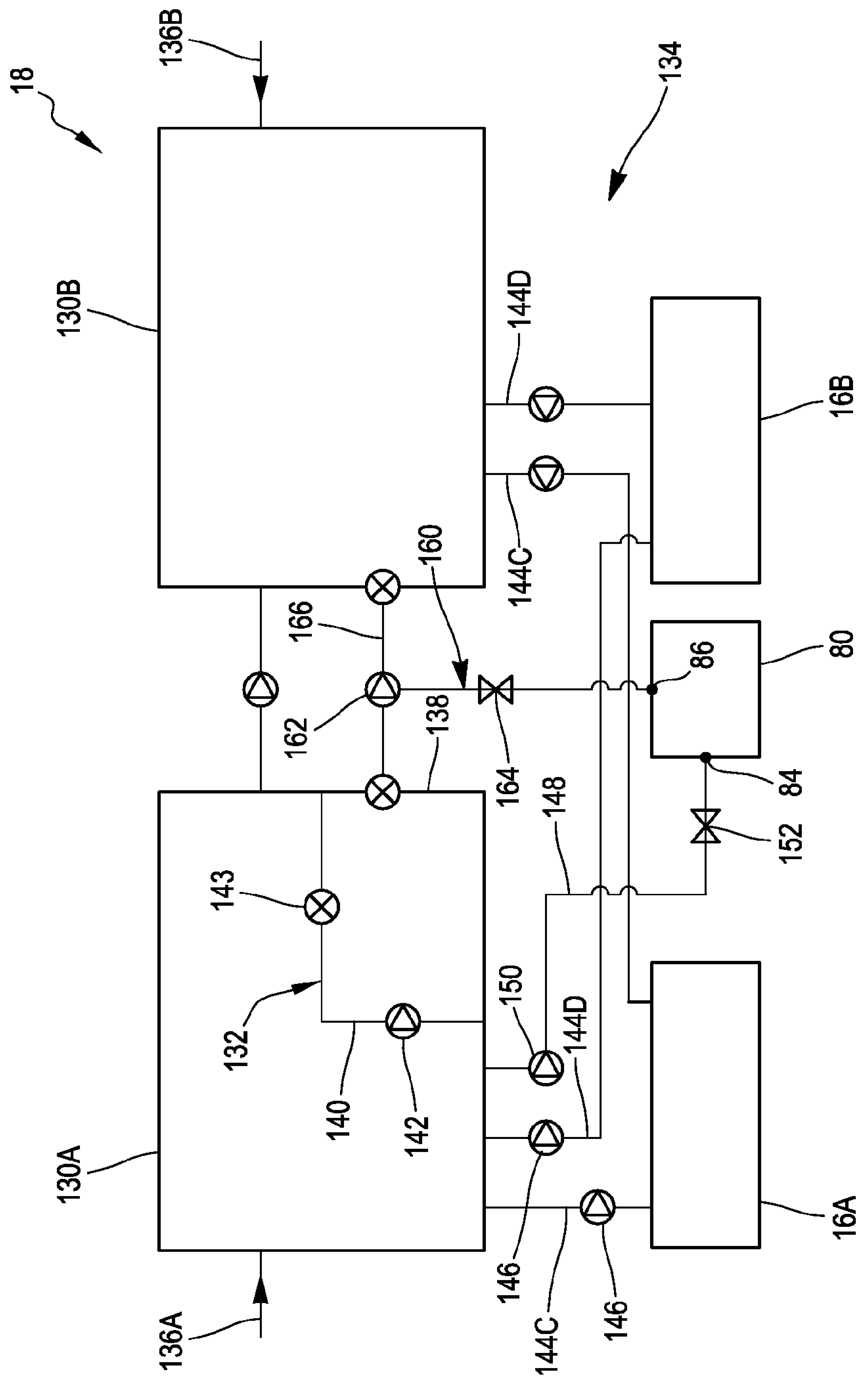
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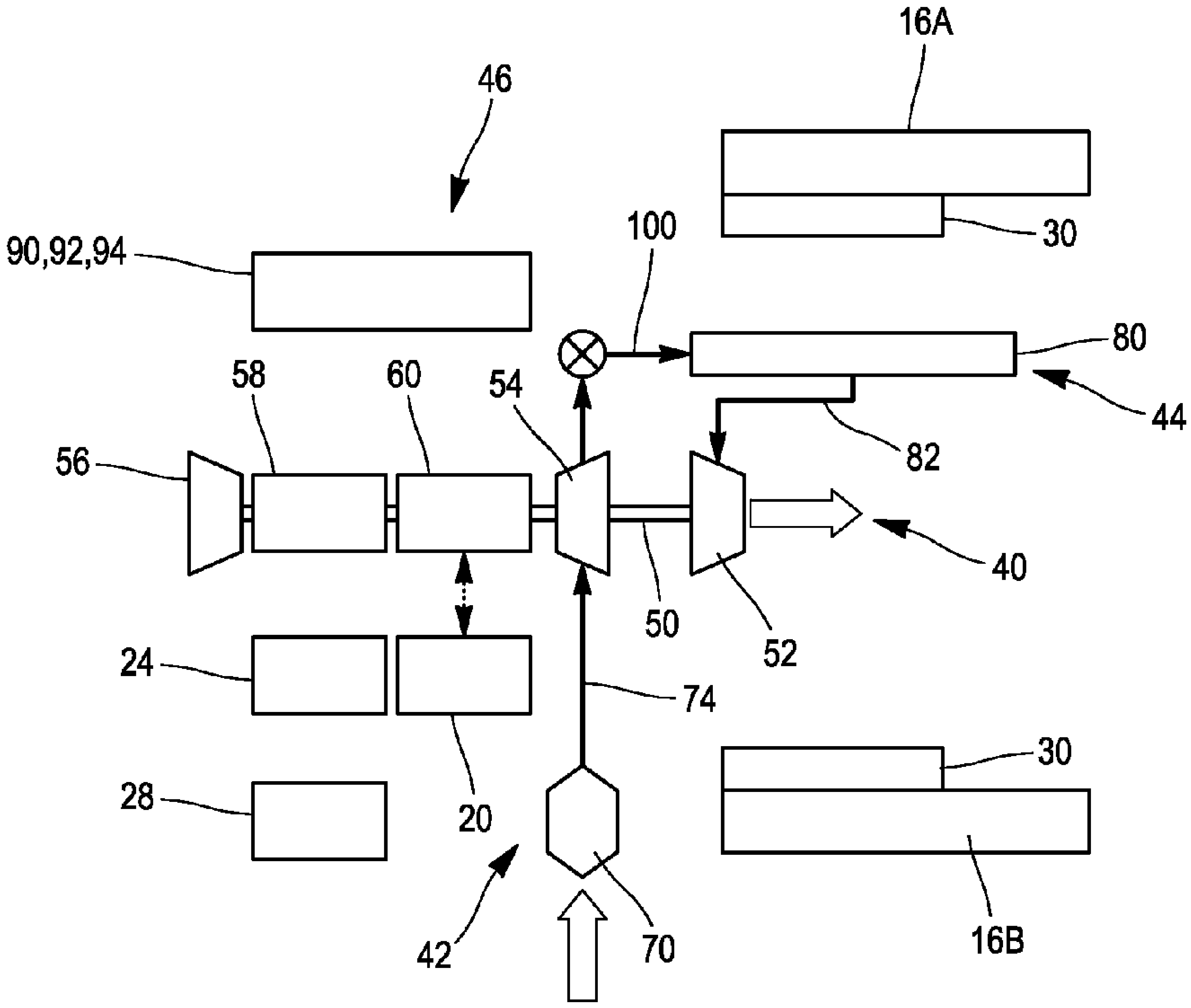
FIG.2

FIG.3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16B

FIG.4

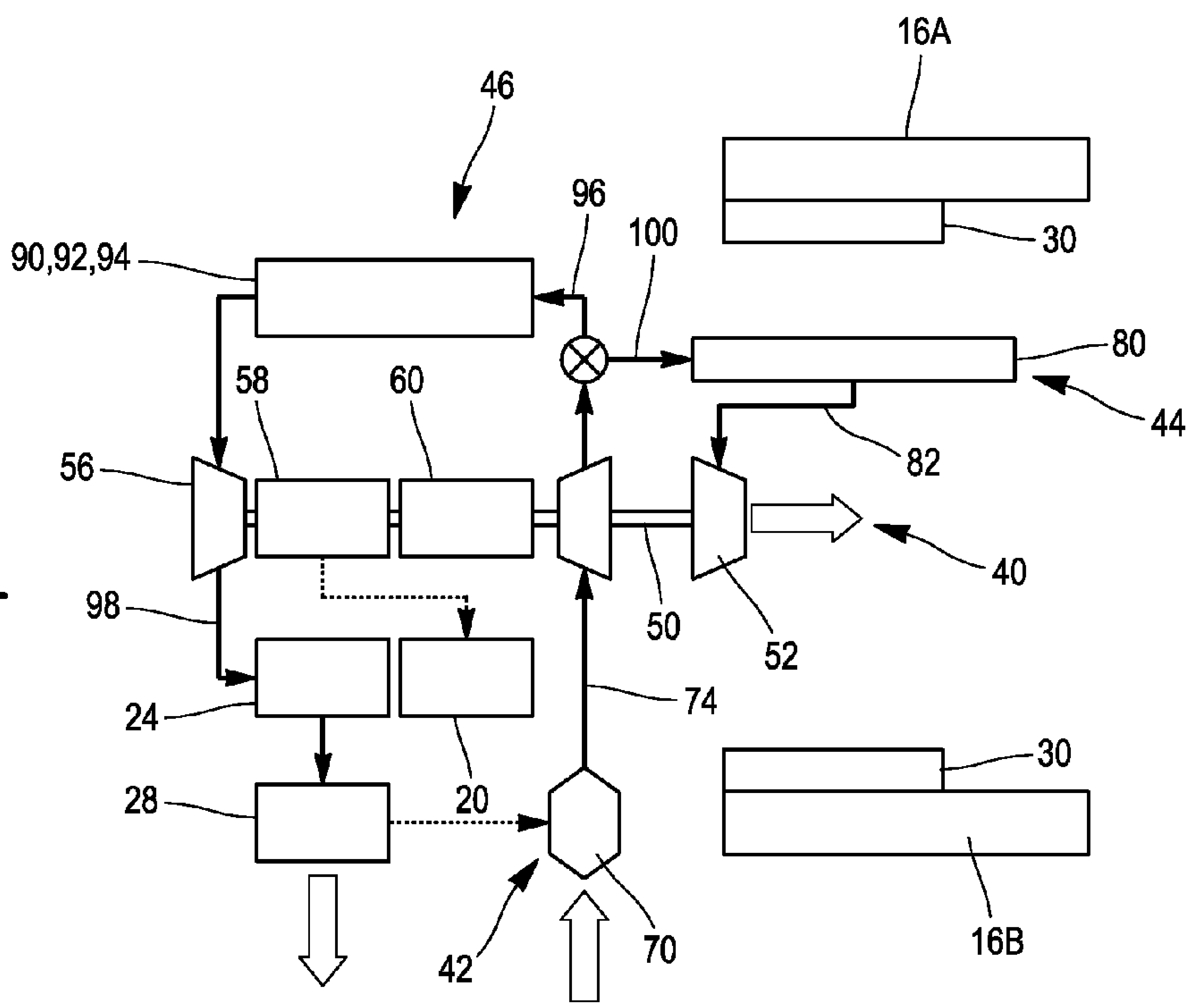
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FIG.5

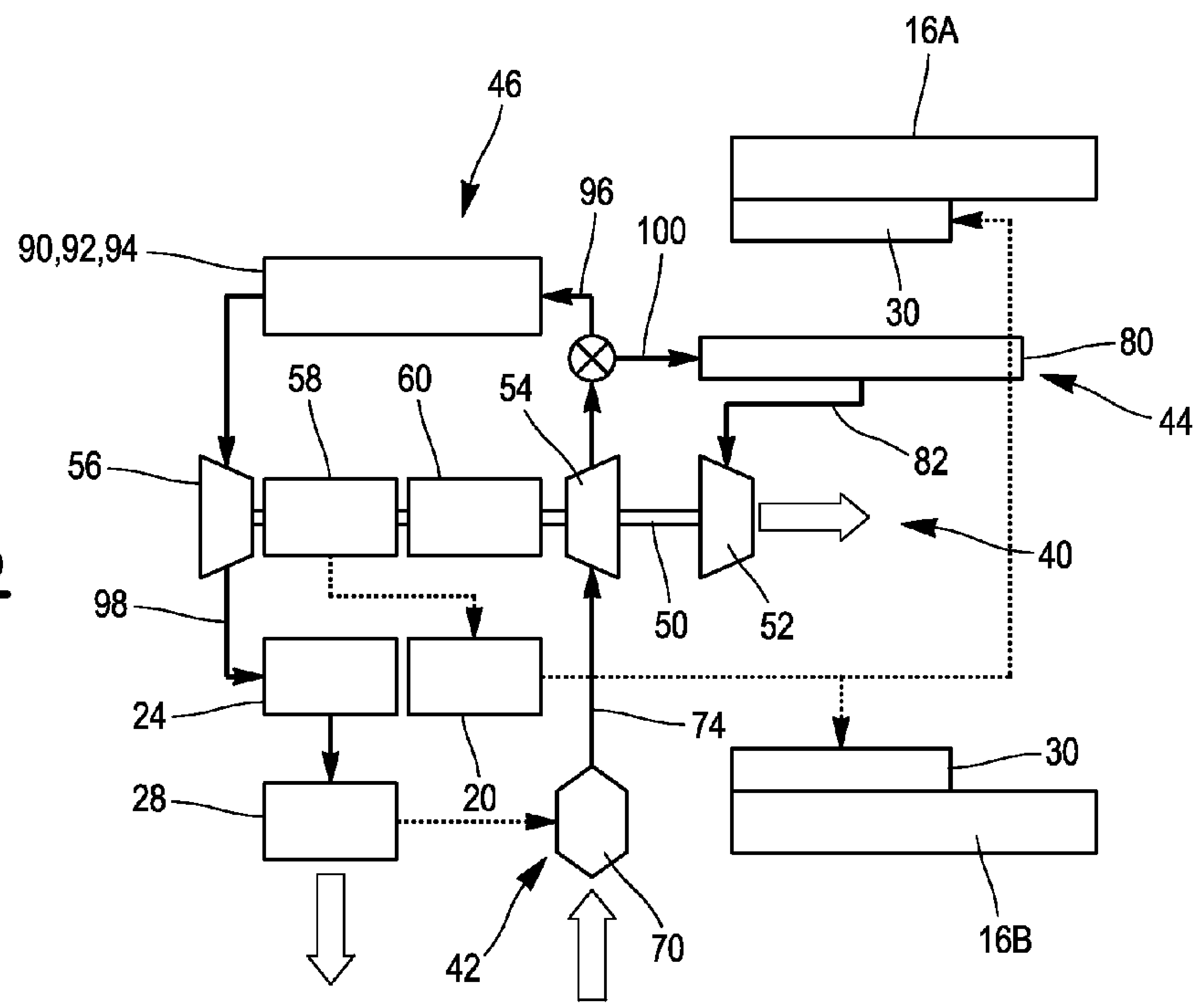
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FIG.6

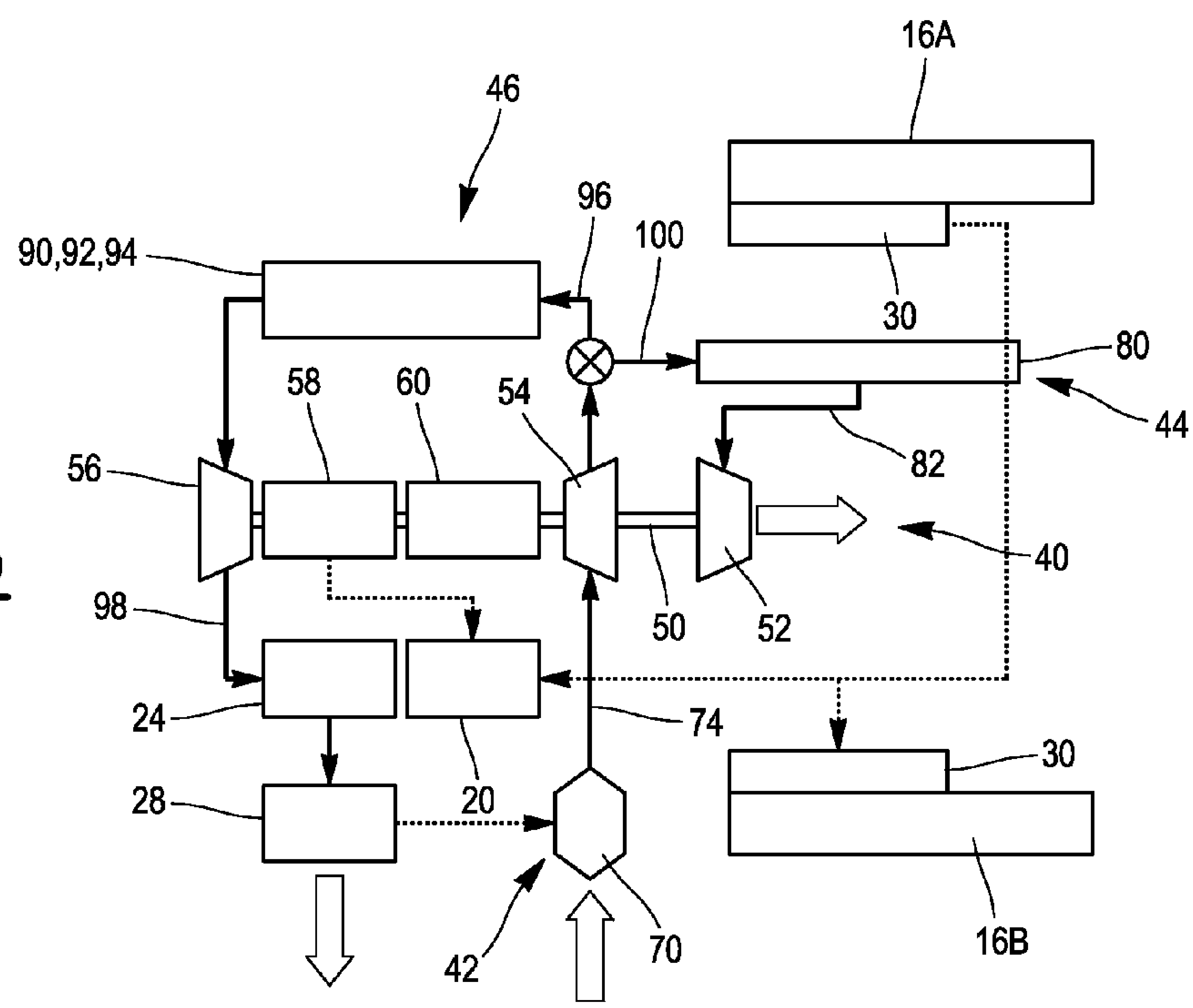
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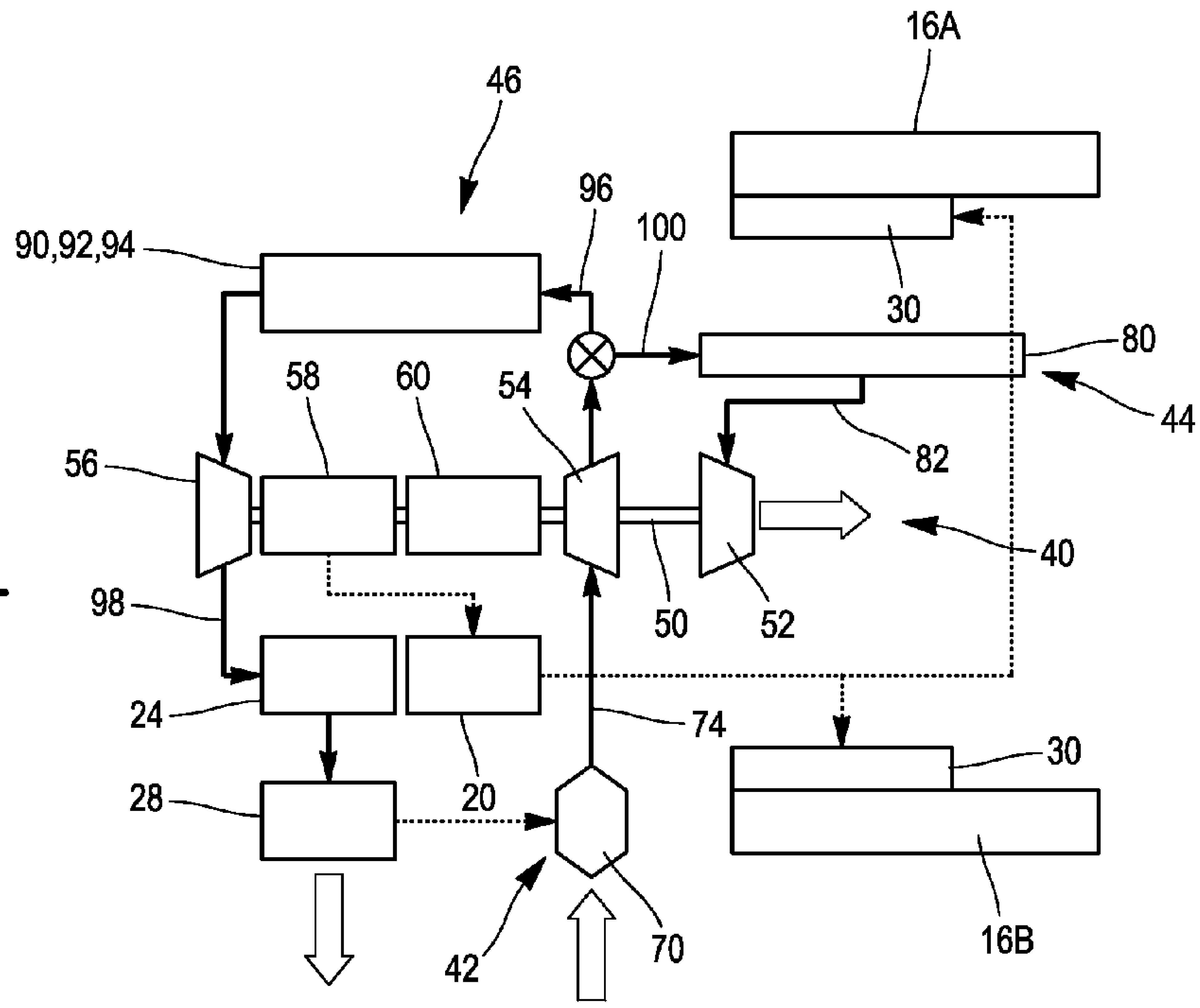
FIG.7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16B
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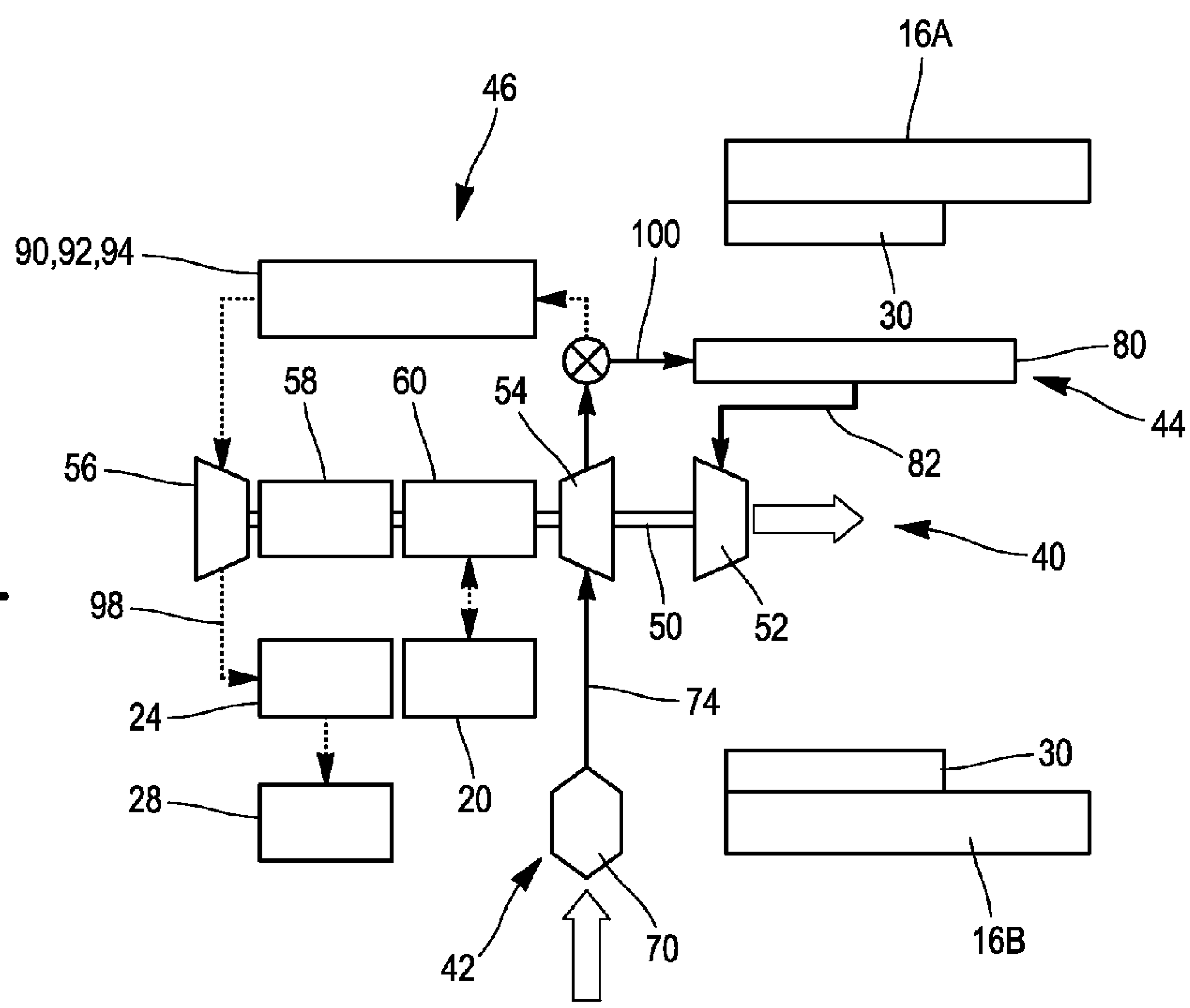
FIG.8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16B
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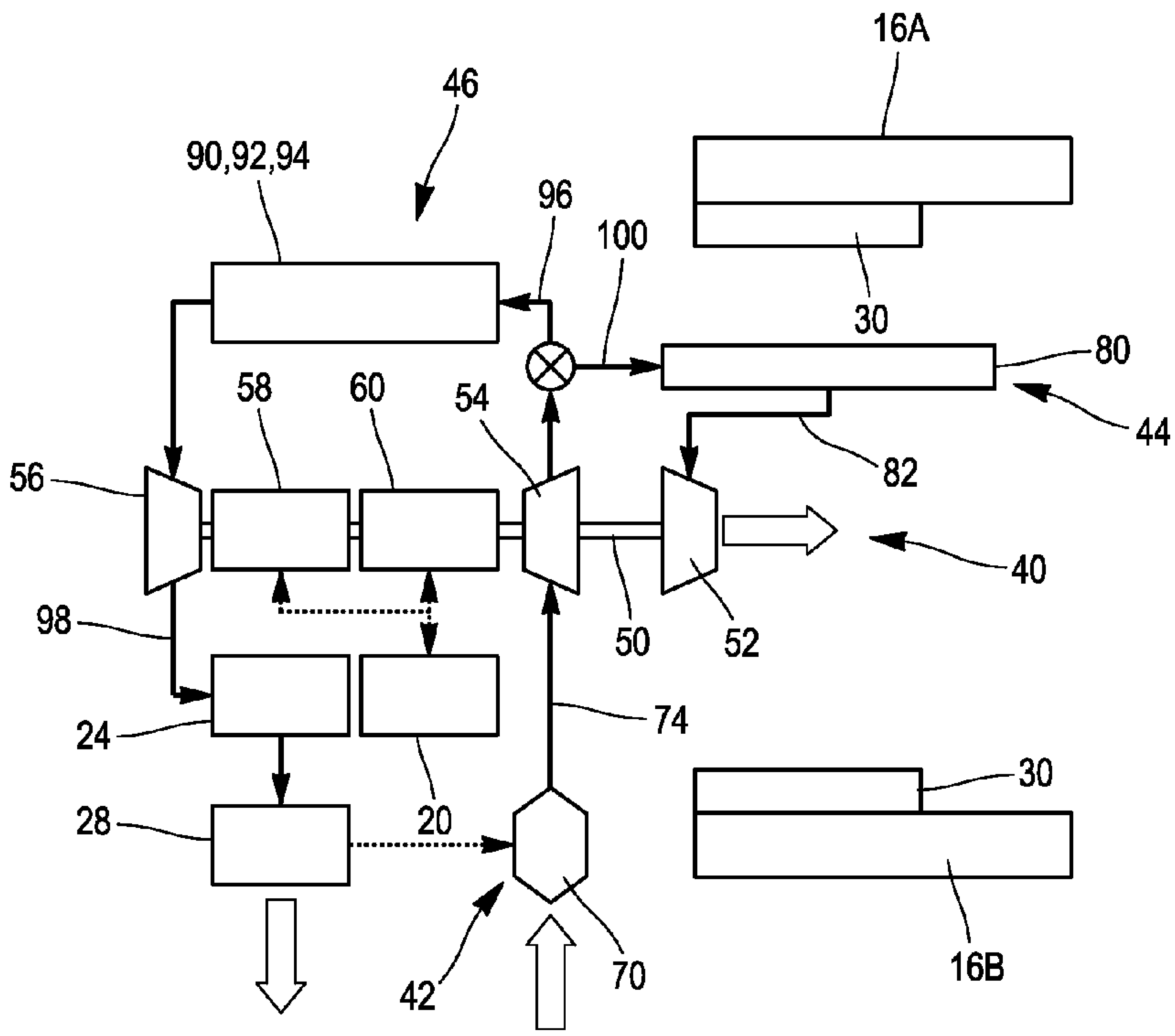
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FIG.9

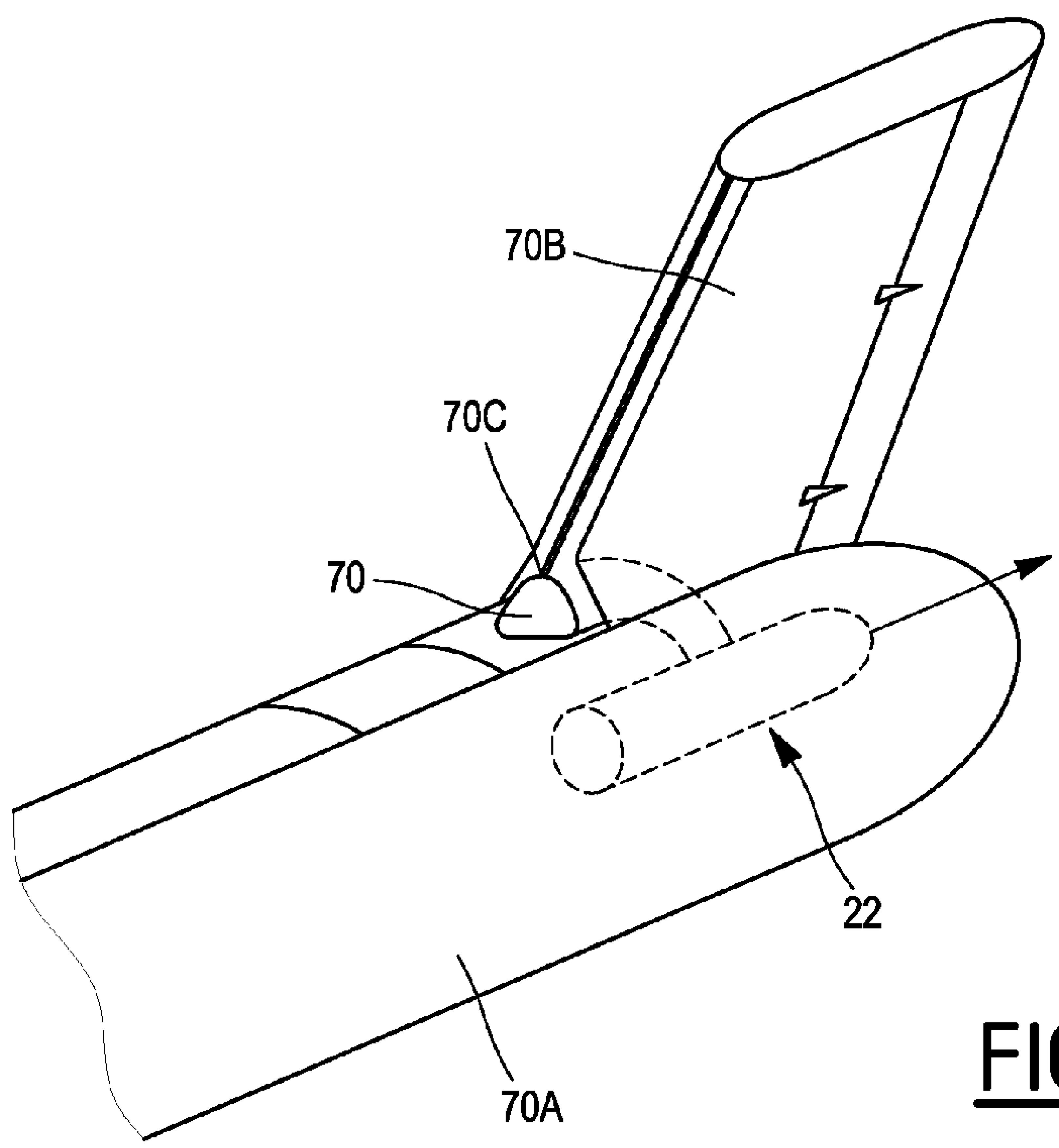
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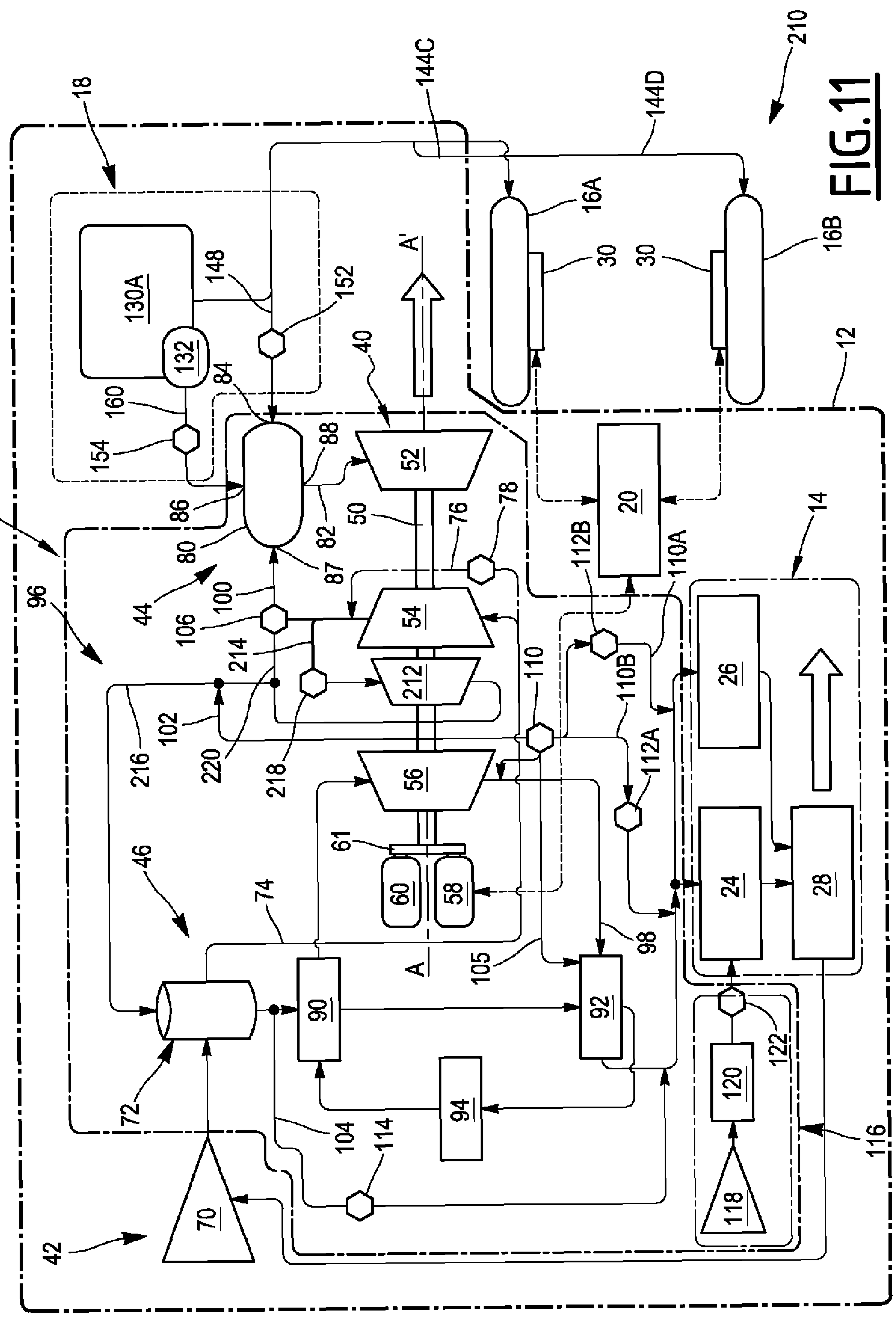
FIG.10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A'
40
52
50
76
78
20
112B
110A
14
22
96
44
100
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214
212
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110B
26
102
216
220
218
56
112A
12
61
60
58
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74
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90
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72
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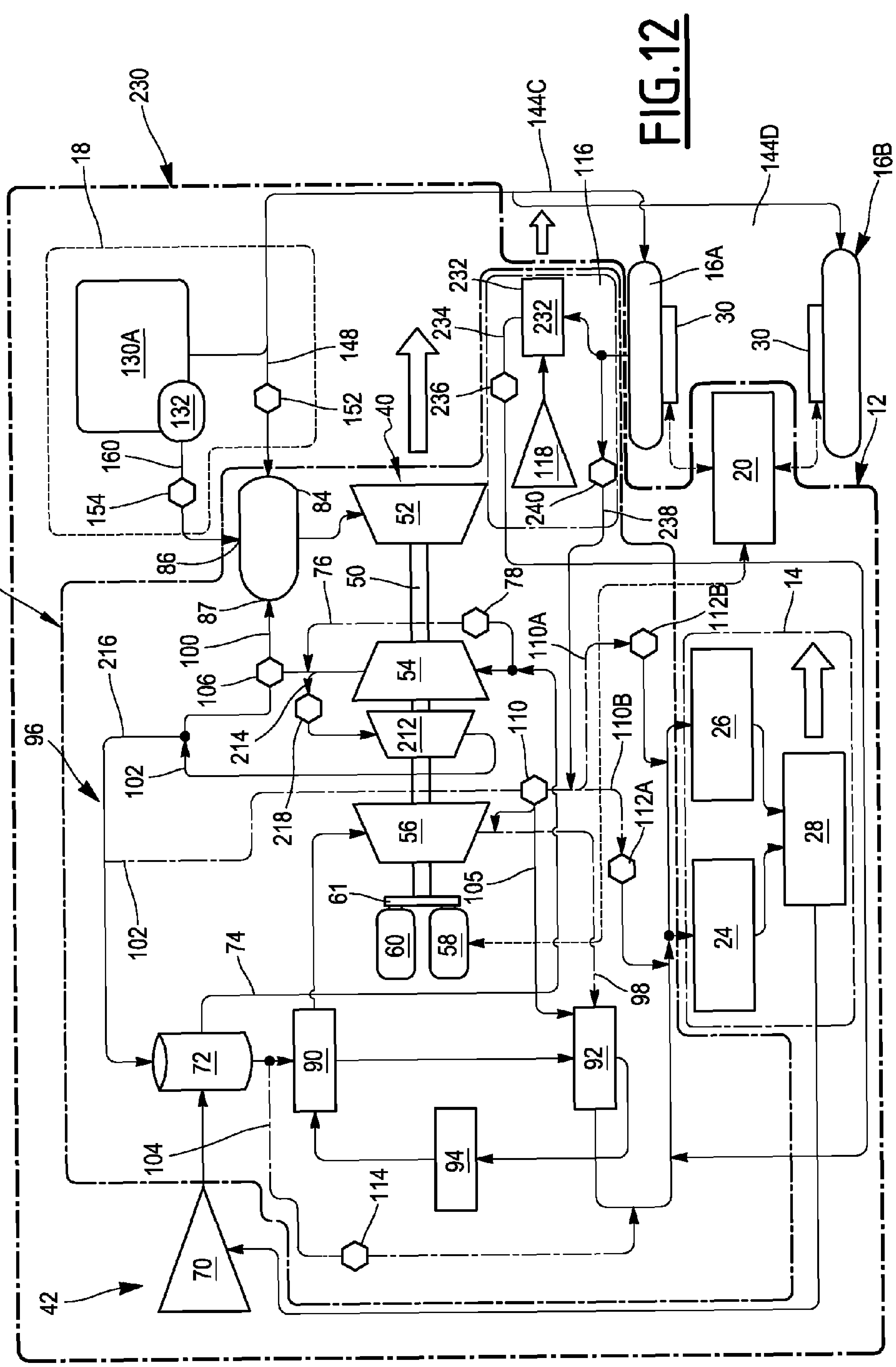
120
122
118
116
70
42

FIG.11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112B
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212
110
110B
26
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FIG. 12

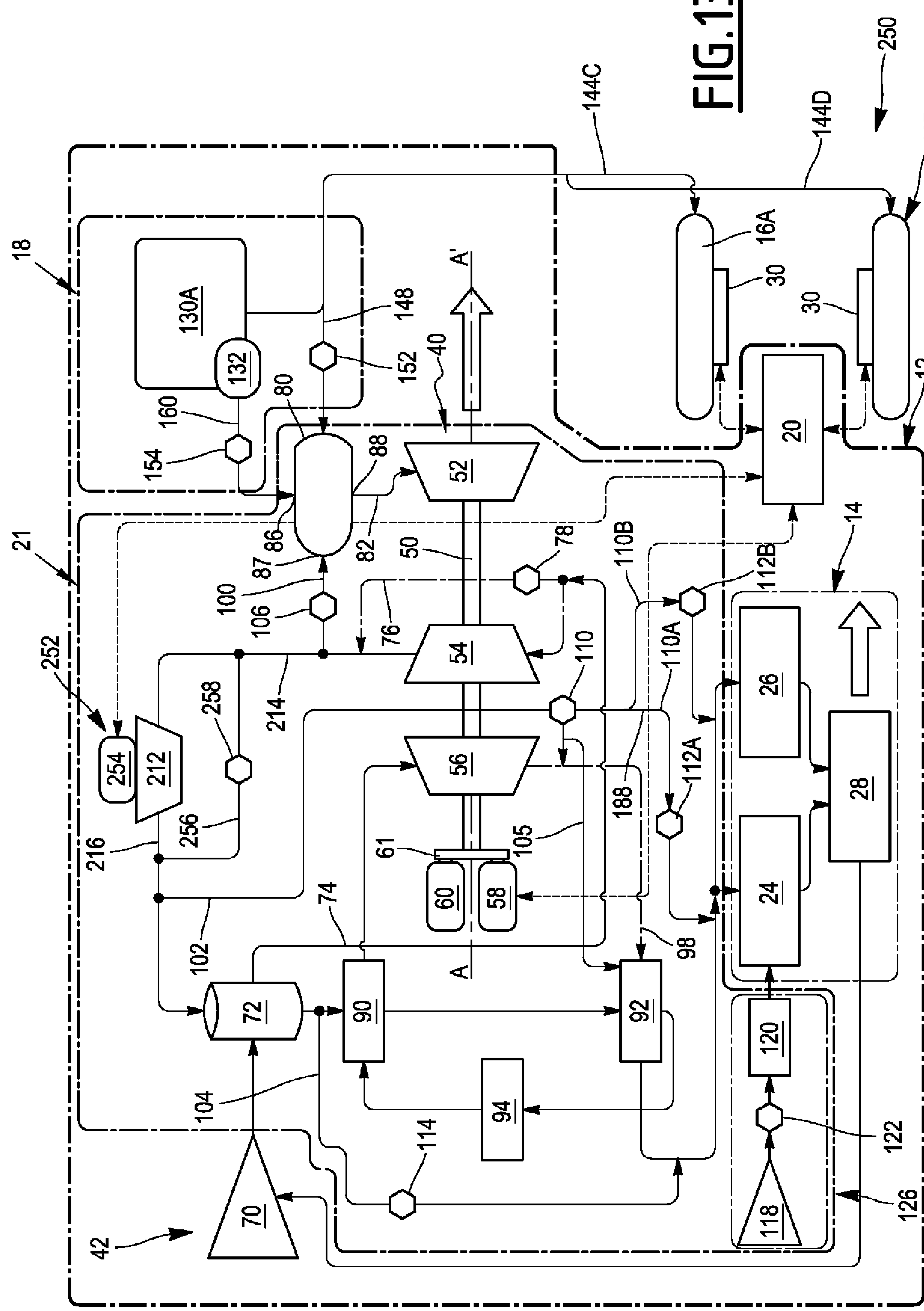

FIG.13

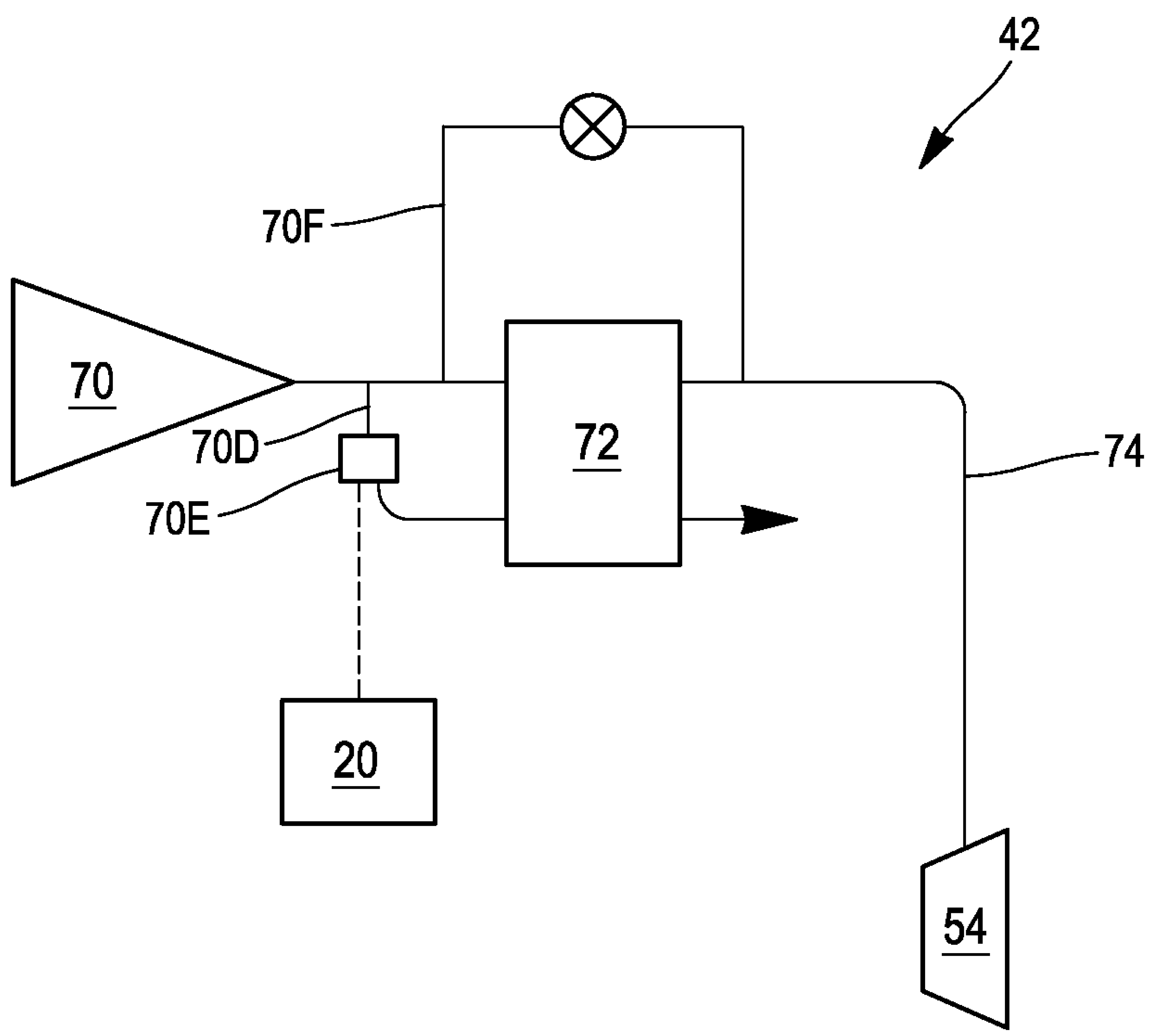

FIG.14

AUTONOMOUS ELECTRICITY PRODUCTION AND CONDITIONING SYSTEM FOR AN AIRCRAFT, ASSOCIATED AIRCRAFT AND METHOD

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an autonomous electricity production and conditioning system for an aircraft, including:

- a rotary shaft;
- a compressor mounted integral with the rotary shaft;
- a power turbine capable of rotating the rotary shaft;
- a cold expansion turbine rotated by the rotary shaft and supplied with a compressed gas from the compressor.

Such a system is in particular intended to be used on a civilian aircraft, such as a passenger and/or freight airplane, or on any other flying vehicle.

2. Brief Discussion of the Prior Art

In aircrafts, it is necessary to have a system performing temperature, pressure and hygrometry conditioning functions of the aircraft. Such a system is generally designated as an "Environmental Control System" or "ECS."

Such a system comprises a compressor and a cold turbine mounted on a same shaft. The compressor is generally fed with air from an engine withdrawal or from an air turbogenerator. The compressed air, after cooling and drying, is expanded in the cold turbine to produce the frigories necessary for conditioning of the aircraft.

Generally, the aircraft is also provided with an air turbogenerator (ATG, also called APU, or "auxiliary power unit") intended to produce electricity and air for the aircraft's needs. This turbogenerator includes a power turbine supplied with combustion gases produced in a combustion chamber independent of the engine(s) of the apparatus. A compressor is mounted on the shaft of the power turbine to allow pressurized air production on the ground, and to supply the combustion chamber.

The presence of these two systems on a same aircraft has drawbacks in terms of weight and bulk.

To offset this problem, US 2010/0170262 describes an autonomous system of the aforementioned type, in which a power turbine supplied by a combustion chamber, a compressor, and a cold expansion turbine intended to produce a cold gas for the environmental control system are mounted on a same shaft.

To feed the compressor, a withdrawal is done in a low-pressure zone of a propulsion engine of the aircraft. This withdrawal provides hot air leaving the engine to supply the intake of the compressor. This hot air is generally conveyed to the compressor by passing through a heat exchanger to condition it at the right temperature.

Such a system reduces the onboard weight and volume, while preserving the necessary functionalities for the aircraft. Thus, when the propulsion engines are turned off, the combustion chamber can be activated to rotate the power turbine, the compressor and the cold turbine so as to allow conditioning of the cabin. Furthermore, when an alternator is driven by the shaft supporting the turbines and the compressor, the rotation of the alternator creates electricity necessary for the needs of the aircraft, in the absence of primary electricity production provided by the alternators coupled to the engines of the aircraft.

Once the engines are started, they supply the conditioning system(s) with air.

Such an assembly is not fully satisfactory, in particular on civilian airplanes. In fact, all of the gas provided at the intake of the compressor comes from the engine.

When the engine is off, or when it is not working correctly, the compressor must suction air through the immobile blades and the structure of the engine, which significantly increases the pressure loss to be overcome. The compressor must therefore be oversized, which increases its bulk, mass and consumption. Furthermore, the engine air withdrawal intended for the compressor of the conditioning system directly influences the thermodynamic cycle of the engine, which increases the consumption thereof.

Furthermore, the existing standards on civilian airplanes require a maximum usage temperature of the engine gases that is restrictive. This temperature is 204° C. However, the temperature of the withdrawn gases is much higher, for example in the vicinity of 260° C. These gases must therefore be cooled by an air-air exchanger before being conveyed into the aircraft, which causes significant energy consumption.

The sizing of the system, and in particular of the air intakes in the engine, is complex to perform, and requires compromises between optimal thermodynamic use of the engine and the conditioning system.

SUMMARY OF THE INVENTION

One aim of the invention is to obtain an autonomous power production and conditioning system that is compact and light, while being more economical in terms of fuel consumption.

To that end, the invention relates to a system of the aforementioned type, characterized in that the system comprises an upstream assembly supplying outside air to the aircraft not having passed through a propulsion engine of the aircraft, the upstream supply assembly being connected to an inlet of the compressor.

The system according to the invention may include one or more of the following features, considered alone or according to any technically possible combination:

- It comprises a combustion chamber, independent of the or each propulsion engine of the aircraft, the system including a channel for supplying the power turbine with at least one combustion gas from the combustion chamber;
- It comprises a hose for withdrawing a compressed gas from the compressor emerging in the combustion chamber;
- It comprises an auxiliary compressor arranged downstream of the compressor and upstream of the cold turbine to receive at least part of the compressed gas from the compressor, the withdrawal hose being tapped between the compressor and the auxiliary compressor upstream of the auxiliary compressor;
- The auxiliary compressor is rotated by the rotary shaft;
- The auxiliary compressor is positioned away from the rotary shaft, the system comprising an auxiliary motor for rotating the auxiliary compressor, advantageously an electric motor rotated by electricity supplied by an electrical network of the aircraft;
- The supply assembly comprises an upstream heat exchanger capable of placing the air outside the aircraft not having passed through a propulsion engine of the aircraft in a heat exchange relationship with at least part of the compressed gas from the compressor;
- It comprises a downstream heat exchanger, a condenser, and a separator that are capable of receiving at least part of the compressed gas from the compressor, to produce a compressed gas intended to be introduced into the cold turbine, the condenser being able to place a cooled

expanded gas from the cold turbine in heat exchange with a compressed gas from the downstream heat exchanger;

It comprises at least one gas distribution hose for an expanded gas from the cold turbine toward an enclosure of an aircraft intended to be conditioned;

It comprises a member for transmitting the rotational movement of the rotary shaft mechanically connected to the rotary shaft, advantageously a speed reducer;

It comprises a main alternator mechanically connected to the rotary shaft; and

It comprises a secondary alternator separate from the main alternator, the secondary alternator being mechanically connected to the rotary shaft.

The invention also relates to an aircraft comprising a system as defined above and a fuel storage device,

the storage device advantageously comprising:

at least one main reservoir, the or each main reservoir being intended to contain a first batch of fuel;

at least one feed line for supplying a propulsion engine of the aircraft with the first batch of fuel contained in the main reservoir;

at least one auxiliary reservoir, designed to contain a second batch of fuel separate from the first batch of fuel, the auxiliary reservoir being connected to the main reservoir, the device comprising an intake line for bringing the second batch of fuel contained in the auxiliary reservoir toward a combustion chamber of the aircraft independent of the or each engine of the aircraft.

The invention also relates to a method for conditioning an aircraft, including the following steps:

providing a system as defined above;

activating the power turbine to rotate the rotary shaft;

jointly rotating the compressor and the expansion turbine;

supplying the compressor with air outside the aircraft not having passed through a propulsion engine of the aircraft.

The method according to the invention includes one or more of the following features, considered alone or according to any technically possible combination:

The system comprises a combustion chamber, the method including the following steps:

activating the combustion chamber to produce a combustion gas;

supplying the power turbine with the combustion gas;

withdrawing at least part of the compressed gas from the compressor to supply the combustion chamber;

It comprises a step for introducing, into the cold turbine, a compressed gas from the compressor conveyed through the transport pipe.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

The invention will be better understood upon reading the following description, provided solely as an example, and done in reference to the appended drawings, in which:

FIG. **1** is an overview flowchart of a first aircraft according to the invention, provided with an autonomous power generation and conditioning system, supplied by a fuel storage device according to the invention;

FIG. **2** is an overview flowchart of the fuel storage device according to the invention;

FIG. **3** is an overview flowchart showing the autonomous production assembly in a first operating phase on the ground;

FIG. **4** is a view similar to FIG. **3** during a second operating phase on the ground;

FIG. **5** is a view similar to FIG. **3** during ignition of the engine;

FIG. **6** is a view similar to FIG. **3** during a flight under normal conditions of the aircraft;

FIG. **7** is a view similar to FIG. **6** when an engine is restarted;

FIG. **8** is a view similar to FIG. **7** during a burnout of the engines;

FIG. **9** is a view similar to FIG. **3** during maintenance operations;

FIG. **10** is a partial perspective view of the rear portion of an aircraft according to the invention;

FIG. **11** is a view similar to FIG. **1** of a second aircraft according to the invention;

FIG. **12** is a view similar to FIG. **1** of a third aircraft according to the invention;

FIG. **13** is a view similar to FIG. **1** of a fourth aircraft returned to the invention;

FIG. **14** is a view of an alternative assembly for providing outside air for the autonomous power production system.

DETAILED DESCRIPTION OF THE INVENTION

Hereafter, the terms “upstream” and “downstream” are generally used in reference to the normal direction of circulation of a fluid.

A first aircraft **10** according to the invention is diagrammatically illustrated by FIG. **1**.

In a known manner, this aircraft **10** comprises a fuselage **12** delimiting an enclosure **14** designed to be conditioned, in particular in terms of temperature and pressure.

The aircraft **10** comprises at least one engine **16**A, **16**B, a fuel storage device **18**, an electric network **20**, and an autonomous electricity production and conditioning system **22**.

The enclosure **14** comprises a cabin **24** intended to transport passengers and/or goods, a cockpit **26**, intended to transport a crew piloting the aircraft **10**, and a cargo compartment **28** intended to transport luggage and/or goods and/or functional equipment of the aircraft.

The passengers, luggage, goods and/or functional equipment must be transported under predefined temperature, pressure, and hygrometry conditions.

The gas present in the enclosure **14** is conditioned by the autonomous system **22** to have a particular temperature and pressure, independent of the temperature and pressure prevailing outside the aircraft **10**.

Generally, the temperature of the gas present in the enclosure **14** is kept at a reference usually between 15° C. and 60° C. during operation of the zone of the aircraft to be conditioned. Likewise, the pressure of the gas in the enclosure **14** is kept between the atmospheric static pressure situated outside the aircraft, and that static pressure value plus 800 absolute millibars, depending on the areas of the airplane and the altitude thereof.

The aircraft **10** comprises at least one engine **16**A, **16**B intended for the propulsion thereof, in particular to enable the takeoff and maintenance in flight thereof.

In the example illustrated in FIG. **1**, the aircraft **10** comprises two engines **16**A, **16**B, the number of engines **16**A, **16**B more generally being able to be between 1 and 4.

In this example, each engine **16**A, **16**B is a turbojet engine including a turbine rotated by the combustion of a liquid fuel (such as kerosene) to create thrust.

Each engine **16**A, **16**B is equipped with an element **30**. In the case of an electric-start engine, this element is a main production alternator-starter which, when supplied with electricity, is capable of rotating the engine to ensure the ignition thereof. In the case of an air-start engine, this element **30** is a generator. In both cases, this element is rotatably mounted jointly with the turbine to create electricity transmitted to the electric network **20** when the engine **16**A, **16**B is active.

The electric network **20** is designed to supply the functional assemblies of the aircraft **10** with electricity.

The electric network **20** in particular powers a computer, in particular a flight control computer, pumps, navigational instruments, and services present in the cockpit **26** and the cabin **24**.

As illustrated by FIG. **1**, the autonomous system **22** forms an independent power module, capable of generating electricity, independently of the elements **30** (alternator-starters or generators), for example when the engines **16**A, **16**B are stopped.

The autonomous system **22** is also intended to condition the gas present in the enclosure **14**, in particular by supplying a cooled compressed gas.

As illustrated in FIG. **1**, the autonomous system **22** comprises a rotary assembly **40**, an upstream assembly **42** for supplying outside air to the rotary assembly **40**, a combustion assembly **44** for rotating the rotary assembly **40**, and a downstream gas conditioning assembly **46**.

The rotary assembly **40** comprises a single rotary shaft **50**. It also comprises a power turbine **52**, a compressor **54**, and a cold turbine **56**, which are mounted on the rotary shaft **50**.

The rotary assembly **40** also comprises a main alternator **58** and, advantageously, an auxiliary alternator **60**, the alternators **58**, **60** being mechanically connected to the rotary shaft **50** by a transmission member **61** transmitting the rotational movement of the shaft.

The transmission member **61** is for example a rotational speed modifier capable of driving each alternator **58**, **60** at a speed of rotation distinct from that of the shaft **50**, such as a speed reducer.

Alternatively, at least one alternator **58**, **60** is directly supported on the shaft **50**.

As will be seen in more detail below, the rotary assembly **40** is designed to be driven around a shaft axis A-A' by the power turbine **52**. This rotational driving causes the joint rotation of the compressor **54**, the cold turbine **56**, the main alternator **58**, and the auxiliary alternator **60**, by means of the transmission member **61**, when one is present.

According to the invention, the upstream assembly **42** for supplying outside air is intended to supply the compressor **54** with air from outside the aircraft **10** not having passed through a propulsion engine **16**A, **16**B of the aircraft **10**.

In this example, the supply assembly **42** comprises an outside air intake **70**, an upstream heat exchanger **72**, and an outside upstream air intake line **74** connecting the outside air intake **70** to a compressor intake **54**, through the upstream exchanger **72**.

As illustrated by FIG. **10**, the outside air intake **70** is for example formed in the fuselage **70**A (FIG. **10**) of the aircraft **10** to take outside air from the aircraft **10**.

This intake may in particular be situated at the base of the vertical stabilizer **70**B positioned at the rear of the fuselage, for example in a nozzle **70**C.

Alternatively (not shown), the intake **70** is a scoop protruding relative to the fuselage.

According to the invention, the air intake **70** is positioned spaced away from the or each engine **16**A, **16**B. It is provided with fuel injection means. The outside air taken by the intake **70** does not come into contact with the fuel intended for propulsion of the aircraft **10**.

The sizing of the air intake **70** is adapted to the size of the compressor **54** and is independent of the quantity of air present in the or each engine **16**A, **16**B to ensure the propulsion of the aircraft.

Furthermore, the outside air captured at the intake **70** is not used to create a thrust force on the aircraft.

In FIG. **1**, a first outside air bypass line **76** is tapped on the air intake line **74** downstream of the exchanger **72**, and upstream of the compressor **54**, to supply outside air taken by the air intake **70** downstream of the compressor **54**, without passing through the latter.

The first bypass line **76** is provided with a bypass valve **78** of the compressor **54**.

The line **76** is intended to oppose the pumping phenomenon in the compressor **54**.

The combustion assembly **44** comprises a combustion chamber **80** intended to produce a combustion gas having an increased enthalpy, and a channel **82** for supplying the power turbine **52** with combustion gas.

The combustion chamber **80** is intended to receive fuel coming from the storage device **18** either through a main inlet **84**, or through a secondary inlet **86**, as will be seen below. The main inlet **84** and the secondary inlet **86** are situated spaced apart from one another, as will be seen below.

The chamber **80** has a compressed air intake inlet **87** coming from the compressor **54** and a combustion gas outlet **88** on which the supply channel **82** is connected.

The chamber **80** is capable of receiving fuel coming from the storage device **18**, performing the combustion thereof in the presence of compressed air received by the air intake inlet **87**, to produce a gas discharged through the combustion gas outlet **88**.

On the other hand, the combustion chamber **80** is incapable of creating a propulsion gas of the aircraft **10**. It does not form an engine of the aircraft and is independent of the engine(s) **16**A, **16**B of the aircraft **10**.

In particular, the combustion gases produced in the combustion chamber **80** are not intended or able to rotate a turbine of a propulsion engine **16**A, **16**B.

In this example, the downstream conditioning assembly **46** comprises a downstream heat exchanger **90**, a condenser **92**, a separator **94**, and a line **96** for conveying the compressed gas in the compressor **54** toward the cold turbine **56**. The transport line **96** successively passes through the upstream heat exchanger **72**, the downstream heat exchanger **90**, the condenser **92**, the separator **94**, then again through the heater **90**, before reaching the cold turbine **56**.

The downstream assembly **46** also comprises an expanded cold gas distribution line **98** connecting an output of the turbine **56** to the enclosure **14** through the condenser **92**.

The downstream assembly **46** also comprises a compressed air bypass line **100** for supplying the combustion chamber **80**.

In FIG. **1**, the downstream assembly **46** comprises a direct compressed air bypass line **102** from the compressor **54** toward the enclosure **14**, and a bypass line **104** for compressed gas from the exchanger **72** toward the enclosure **14**.

The downstream assembly **46** also comprises a direct bypass line **105** of the compressed gas from the compressor **54** toward the cold turbine **56** and toward the condenser **92** to deice those elements.

The upstream heat exchanger **72** is capable of putting the compressed gas from the compressor **54** circulating in the transport line **96** in a heat exchange relationship with the outside air taken in the air intake **70** to cool the compressed gas and heat the outside air.

The downstream heat exchanger **90** is capable of putting the upstream compressed gas circulating in the transport line **96** at the outlet of the upstream heat exchanger **72** in a heat exchange relationship with the downstream compressed gas from the separator **94** circulating in the transport line **96**, to heat the downstream compressed gas from the separator **94** and cool the upstream compressed gas at the outlet of the heat exchanger **72**.

The condenser **92** is capable of putting the expanded cold gas from the turbine **56** in a heat exchange relationship with the compressed gas from the downstream heat exchanger **90** to cool and potentially partially condense the compressed gas.

The separator **94** is capable of eliminating the liquid phase of the partially condensed compressed gas in the condenser **92** to prevent that liquid phase from entering the cold turbine **56**.

The compressed air bypass line **100** is tapped on the transport line **96** between the outlet of the compressor **54** and the heat exchanger **72**. It emerges in the combustion chamber **80** at the compressed air supply inlet **87**. It is provided with a control valve **106** for the flow of compressed air to be sent toward the combustion chamber **80**.

The direct bypass line **102** comprises a shared upstream section **108** provided with a bypass valve **110** and two downstream sections **110**A, **110**B intended respectively to connect the cabin **24** and the cockpit **26**. Each of the sections **110**A, **110**B is provided with a valve **112**A, **112**B for controlling the injected flow rate.

The compressed gas bypass line **104** is tapped upstream on the transport line **96** between the upstream heat exchanger **72** and the downstream heat exchanger **90**. It emerges downstream on the distribution line **98**, downstream of the condenser **92**. It is provided with a control valve **114** for the bypassed compressed gas flow.

In FIG. **1**, the autonomous power production and conditioning system **22** also comprises an auxiliary backup conditioning assembly **116**.

This auxiliary assembly **116** includes a backup air intake **118**, a backup heater **120**, and a backup ventilation valve **122** that emerges in the enclosure **14**.

The backup air intake **118** is independent and is distinct from the air intake **70**. The backup heater **120** is independent from the combustion chamber **80** and the engines **16**A, **16**B. The heater **120** is advantageously an electric heater electrically powered by the network **20**.

As illustrated in FIG. **2**, the fuel storage device **18** comprises, according to the invention, at least one main reservoir **130**A, **130**B, at least one auxiliary reservoir **132** arranged in the main reservoir **130**A, and a selective fuel distributor **134** toward the or each engine **16**A, **16**B and toward the combustion chamber **80**.

As illustrated by FIG. **2**, the aircraft **10** generally comprises a plurality of main reservoirs **130**A, **130**B arranged in the wings or in the fuselage **12** of the aircraft. Each main reservoir **130**A, **130**B can contain a first batch of liquid fuel intended to supply the engine(s) **16**A, **16**B for propulsion of the airplane.

Each main reservoir **130**A, **130**B is also intended to supply the combustion chamber **80** in a normal operating mode.

When several main reservoirs **130**A, **130**B are present, the reservoirs **130**A, **130**B are connected to one another to make it possible to balance the quantity of fuel in the various reservoirs **130**A, **130**B during the flight phases.

Each reservoir **130**A, **130**B is provided with an inlet **136**A, **136**B for supplying a first batch of fresh fuel, the inlet **136**A, **136**B being intended to fill the reservoir **130**A, **130**B between two flights.

According to the invention, the auxiliary reservoir **132** is intended to contain a second batch of fuel separate from the first batch of fuel. The second batch of fuel is for example made up of the first batch of fuel used during a preceding flight, or a batch of fuel obtained from another filling vehicle different from that used to fill the or each main reservoir **130**A, **130**B with fuel.

When a second filling vehicle is used, the second batch of fuel can be filtered and/or tested beforehand to verify the quality and reliability thereof.

In the embodiment illustrated in FIG. **2**, the auxiliary reservoir **132** is positioned inside the main reservoir **130**A. It advantageously shares at least one outer wall **138** with the main reservoir **130**A. The auxiliary reservoir **132** is delimited by an insulating wall **140** sealed against the fuel present in the inner volume of the reservoir **130**A containing it.

The volume of the auxiliary reservoir **132** is less than 15% of the volume of the main reservoir **130**A.

The main reservoir **130**A and the auxiliary reservoir **132** are connected to one another by a fuel exchange pump **142** between the main reservoir **130**A and the auxiliary reservoir **132**.

An overpressure valve **143** also connects the auxiliary reservoir **132** to the main reservoir **130**A.

The insulating wall **140** is for example flexible and deformable so that the auxiliary reservoir **132** has a variable volume depending on the quantity of fuel contained in the auxiliary reservoir. Alternatively, the insulating wall **140** can be a rigid wall, defining a constant volume.

The distributor **134** comprises, for each main reservoir **130**A, **130**B, a supply line **144**C, **144**D connecting the reservoir **130**A, **130**B to each engine **16**A, **16**B.

Thus, in the example shown in FIG. **2**, the first main reservoir **130**A is connected to the first engine **16**A by a first supply line **144**C and is connected to the second engine **16**B by a second supply line **144**D. Likewise, the second main reservoir **130**B is connected to the first reactor **16**A by a first supply line **144**C and to the second reactor **16**B by a second supply line **144**D.

Each of the supply lines **144**C, **144**D is provided with pumping means **146** for the first batch of fuel.

Furthermore, to make it possible to supply the combustion chamber **80**, the distributor **134** comprises at least one first fuel intake line **148** into the combustion chamber **80** intended to convey, into the chamber **80**, the first batch of fuel present in the main reservoir **130**A. This line **148** is provided with a pump **150** and a flow rate control valve **152**. The first line **148** emerges in the combustion chamber **80** through the main inlet **84**.

According to the invention, the distributor **134** also comprises a second intake line **160** for bringing fuel into the combustion chamber **80** intended to convey the second batch of fuel present into the auxiliary reservoir **132**.

The second intake line **160** supplies the chamber **80** exclusively with fuel from the second batch present in the auxiliary reservoir **132**, without being mixed with or contaminated by the first batch of fuel present in the main reservoir **130**A.

The second line **160** is provided with a backup auxiliary pump **162** and a flow rate control valve **164**. The second line **160** emerges into the combustion chamber **80** through the secondary inlet **86**, at a distance from the main inlet **84**. This ensures that an obstruction of the main inlet **84** does not prevent the distribution of the second batch of fuel in the combustion chamber **80**.

To ensure the renewal of the batch of fuel contained in the auxiliary reservoir **132**, a discharge connection **166** is provided on the second intake line **160**, downstream of the pump

162. This discharge connection **166** is for example oriented toward a discharge outside the aircraft **10** or to a main reservoir **130**B.

To guarantee that the auxiliary reservoir **132** of the storage device **18** always comprises a second batch of fuel separate from the first batch and that is reliable, the filling method of the device **18** is as follows.

During the first filling of the reservoirs, before a flight of the aircraft **10**, the main reservoir **130**A, **130**B is filled with a first batch of fuel through the inlet **136**A, **136**B.

The secondary reservoir **132** is filled with a second batch of fuel coming from a source distinct from the first batch of fuel supplied in the main reservoir **130**A, **130**B. In this way, two distinct fuel filling vehicles respectively containing the first batch of fuel and the second batch of fuel are generally used. The second batch of fuel can be filtered and/or tested beforehand to verify the integrity and reliability thereof.

During the flight, the first batch of fuel is used to supply the engines **16**A, **16**B for propulsion of the aircraft, through the supply lines **144**A, **144**B.

Once the aircraft **10** has landed and before a subsequent flight of the aircraft **10**, part of the first batch of fuel present in the main reservoir **130**A is conveyed toward the auxiliary reservoir **132**, through the fuel exchange pump **142**, after discharging the second batch of fuel present in the auxiliary reservoir **132** through the discharge connection **166**.

The first batch of fuel having served for propulsion of the aircraft **10** during the earlier flight, it is considered reliable and healthy. This fuel then forms a second batch of fuel for the subsequent flight, the reliability of which is guaranteed.

Then, the main reservoir **130**A is again filled with a new first batch of fuel.

This filling method guarantees that reliable fuel is always present in the auxiliary reservoir **132**. This ensures that the combustion chamber **80** can be supplied with reliable fuel in case of emergency, as will be described below.

The operation of the autonomous power production and conditioning system **22** according to the invention will now be described, in the various embodiments thereof, using FIGS. **3** to **10**.

Initially, in a machine startup mode, in reference to FIG. **3**, the aircraft **10** is on the ground. The engines **16**A, **16**B are off.

To start the autonomous system **22**, the electric network of the aircraft **20** comprising batteries is electrically connected to the auxiliary alternator **60** to supply said alternator **60** and cause it to operate as an engine. The rotation of the auxiliary alternator **60** makes it possible to test the proper operation thereof before each flight, so as to guarantee that it will be operational in case of emergency, and in particular in the event the main alternator **58** fails.

The rotational driving of the shaft **50** by the auxiliary alternator **60** causes the rotation of the compressor **54** and the suction of outside air through the air intake **70**, and the outside air intake line **74**. This outside air does not pass through a propulsion engine of the aircraft. It lacks fuel.

The valve **106** is then opened to make it possible to supply the combustion chamber **80** with the compressed air from the compressor **54** through the bypass line **100**.

When the flow of air circulating toward the combustion chamber **80** through the bypass line **100** is sufficient, fuel from the main reservoir **130**A, **130**B is injected into the combustion chamber **80** through the supply line **148** and the valve **152**.

The combustion chamber **80** is then ignited to cause the combustion of the fuel, which creates a pressurized combustion gas. The pressure of the combustion gas is for example greater than 1.5 bar, and the temperature thereof is higher than 600° C.

This combustion gas is then extracted through the supply channel **82** and is conveyed to the power turbine **52**.

When the power turbine **52** has enough energy to rotate the shaft **50** independently, the auxiliary alternator **60** is deactivated.

Once this is done, in a nominal operating mode of the system **22** on the ground, or with engines off, shown in FIG. **4**, a continuous flow of outside air is suctioned by the air intake **70** and the intake line **74**. This outside air is injected at the inlet of the compressor **54** to produce a compressed gas delivered into the transport line **96**.

The pressure of the compressed gas from the compressor **54** is for example greater than 1.5 bar (on the ground or at a low altitude, less than 15,000 feet).

Part of the compressed gas from the compressor **54** is then conveyed to the upstream heat exchanger **72**.

Then, the compressed gas from the upstream heat exchanger **72** is introduced into the downstream heat exchanger **90** to be cooled therein. The compressed gas from the downstream heat exchanger **90** then goes into the condenser **92** to be partially condensed therein by heat exchange with the expanded gas from the cold turbine **56** circulating in the downstream line **98**.

The partially condensed compressed gas then penetrates the separator **94**, where the liquid fraction it contains is eliminated.

This compressed gas is then introduced into the downstream heat exchanger **90** to be heated therein by heat exchange with the compressed gas from the exchanger **72**, before being introduced into the cold turbine **56**.

Then, the compressed gas is expanded dynamically in the cold turbine **56** to produce an expanded gas cooled to a lower temperature comprised between 3° C. and 20° C. This temperature is below the temperature of the compressed gas from the compressor **54**. The pressure of the expanded gas is at least greater than the reference pressure.

The expanded cooled gas is then passed into the condenser **92** through the downstream distribution line **98**, before being distributed in the enclosure **14**, in particular in the cabin **24**, the cockpit **26**, and the cargo area **28**.

To that end, and to ensure the temperature, pressure, and hygrometry reference in the cabin **24** and the cockpit **26**, the expanded cooled gas from the condenser **92** is mixed with pressurized compressed gas bypassed by means of the direct bypass line **102**. The flow control valves **112**A, **1128** are thus selectively steered to guarantee a gas injection at a temperature, pressure, and hygrometry selectively commanded in the cabin **24** and the cockpit **26**. Generally, the cargo area **28** is supplied with gas extracted outside the cabin **24** and the cockpit **26**.

It is therefore possible to condition the gas present in the enclosure **14**, even when the engines **16**A, **16**B are off. The system **22** is capable of performing that conditioning independently.

When the shaft **50** is rotated, the main alternator **58** operates as a generator and provides electric power to the electric network **20** of the aircraft, and in particular to the batteries present in the network **20**.

Then, in an electric-start mode of the engines **16**A, **16**B, in reference to FIG. **5**, the engines **16**A, **16**B can be started up using alternator-starters **30**.

To that end, the electric network **20** electrically powers each alternator-starter of the engine **30** so that it operates as an engine and rotates the turbine present in the engines **16**A, **16**B.

A flow of fuel present in the main reservoir **130**A, **130**B is then injected into the engines **16**A, **16**B through the intake lines **144**C, **144**D. The or each engine **16**A, **16**B is then started as illustrated in FIG. **6**.

Once the or each engine **16**A, **16**B is started, the aircraft **10** can take off.

In an alternative air-start of the engines **16**A, **16**B, compressed gas from the compressor **54**, taken upstream of the heat exchanger **72**, is bypassed toward the or each engine **16**A, **16**B to rotate the turbines of those engines. The engine **16**A, **16**B is then started under the effect of that air circulation without it being necessary to use an alternator-starter, the sole purpose of the generator **30** in that case being to generate the current when the engines are operating.

A "complementary electric cogeneration" nominal operating mode, during a flight phase or a ground phase with engines on, is shown in FIG. **6**. In this mode, the elements **30** present on the engines **16**A, **16**B operate as generators and supply the electric network **20** with electricity.

Likewise, the combustion chamber **80** continues to operate continuously, independently relative to the engines **16**A, **16**B, which ensures the conditioning of the enclosure **14** as described above and which produces complementary electricity for the electric network **20** of the aircraft **10**, in particular when additional electricity is necessary.

In an in-flight start-up mode shown in FIG. **7**, where an engine **16**A, **16**B shuts down during flight, the engine **16**A, **16**B may be restarted from the electricity supplied by the independent production system **22** according to the invention.

In that case, the shaft **50** is rotated by supplying the power turbine **52** with combustion gas from the combustion chamber **80**. The main alternator **58** then acts as an electricity generator powering the electric network **20**. In the case of electric-start engines, this electricity is used to power the alternator-starter **30** of the engine **16**A, **16**B to be restarted. The alternator-starter **30** then operates as an engine.

Alternatively, the engine **16**A, **16**B is restarted with air using the compressed gas from the compressor **54**, as previously described.

FIG. **8** illustrates the operation of the system **22** in a mode with a loss of main electricity production. Such a mode for example occurs in the event of total burnout of the engines **16**A, **16**B, i.e. when all of the engines **16**A, **16**B of the device are unusable, and/or when the alternator-starters (in alternator mode) or the generators **30** no longer supply electrical power.

During this emergency procedure, the first batch of fuel present in the main reservoir **130**A, **130**B can be considered a potential source of breakdowns (fuel pollution). In that case, to guarantee a minimal electricity supply for the essential functionalities of the aircraft, the second batch of fuel present in the auxiliary reservoir **132** is used.

To that end, the fuel present in the auxiliary reservoir **132** is transported through the second supply line **160** by means of the pump **162** and the flow control valve **164** to the combustion chamber **80**.

The combustion chamber **80** is therefore supplied with fuel by a second batch of fuel that is healthy unreliable, since that fuel was used without problems during an earlier flight, or was specifically tested on the ground.

In the event the main alternator **58** is broken, the auxiliary alternator **60**, which has been tested beforehand during the start-up of the aircraft **10**, is used to operate as an electricity generator.

The rotation of the shaft **50**, caused by the combustion of the second batch of fuel in the chamber **80**, jointly rotates the auxiliary alternator **60**. This creates a minimum quantity of electricity provided to the electric network **20** of the aircraft **10**, for example between 6 kW and 50 kW. The minimal flight control and instrumentation functions of the aircraft **10** are thus ensured to allow the aircraft **10** tend to land.

A low flow of gas, shown by the arrows in broken lines in FIG. **8**, can then circulate between the compressor **54**, the turbine **56**, the cabin **24**, and the cargo area **28**.

FIG. **9** illustrates a maintenance mode of the aircraft **10**, done on the ground, in which the main alternator **58** and/or the auxiliary alternator **60** are rotated from the combustion of a fuel in the combustion chamber **80** independent of the engine (s) **16**A, **16**B. The alternators **58**, **60** are in particular tested in this mode to verify the proper operation thereof.

A second aircraft **210** according to the invention is illustrated in FIG. **11**. Unlike the first aircraft **10**, the rotary assembly **40** of the autonomous system **22** comprises an auxiliary compressor **212** in addition to the main compressor **54**.

The transport line **96** thus comprises an upstream section **214** connecting the main compressor **54** to the auxiliary compressor **212**, and a downstream section **216** connecting the auxiliary compressor **212** to the upstream heat exchanger **72** and then to the cold turbine **56**.

The upstream section **214** is provided with an upstream supply valve **218** of the auxiliary compressor **212**.

Unlike the first aircraft **10**, the compressed air bypass line **100** is tapped on the upstream section **214**, upstream of the upstream valve **218**. A return bleed **220** connects the control valve **106** of the bypass line **100** to the downstream section **216**, to produce a bypass around the downstream compressor **212**.

The bypass line **102** is tapped on the downstream section **216**, downstream of the auxiliary compressor **212**, and upstream of the upstream exchanger **72**.

The autonomous generation and conditioning system **22** is also similar to that of the first aircraft **10**.

The operation of the autonomous system **22** of the second aircraft **210** differs from the operation of the independent system **22** of the first aircraft **10** in that the compressed gas current obtained at the outlet of the first compressor **54** first passes in the upstream section **214**, through the upstream valve **218** as far as the auxiliary compressor **212**.

A first portion of the gas current compressed at a first pressure in the first compressor **54** is bypassed toward the combustion chamber **80** through the bypass line **100** and the control valve **106**, upstream of the auxiliary compressor **212**.

A second portion of the compressed gas current is then recompressed in the auxiliary compressor **212** to reach a pressure greater than the pressure of the gas obtained at the outlet of the main compressor **54**.

Then, the compressed gas from the auxiliary compressor **212** is oriented toward the cold turbine **54** through the main exchanger **72**, the downstream heat exchanger **90**, the condenser **92**, the separator **94**, and the downstream heat exchanger **90** again, as previously described.

In one alternative, the compressed gas from the upstream exchanger **72** is sent directly into the enclosure **14** by means of the compressed gas bypass line **104** and the control valve **114**, without passing through the cold turbine **56**.

A third aircraft **230** according to the invention is diagrammatically illustrated by FIG. **12**.

The third aircraft **230** differs from the second aircraft **210** in that the auxiliary conditioning assembly **116** comprises a backup heat exchanger **232** replacing the heater **120**. The exchanger **232** is capable of putting a hot gas current taken from a propulsion engine **16**A of the aircraft in a heat exchange relationship with a current of outside air taken through the backup air intake **118**.

The outside air current thus heated is brought toward the enclosure **14** by a backup cold air intake line **234** provided with a control valve **236** for controlling the backup cold air flow rate.

Furthermore, the auxiliary assembly **116** comprises a hot air intake line **238** from a propulsion engine **16**A of the aircraft emerging in the enclosure **14**. The line **238** is provided with a control valve **240** for the backup hot air flow sent toward the enclosure **14**.

In the event the autonomous system **22** fails, cold air is taken through the backup air intake **118**. This cold air is partially heated in the backup exchanger **232**, before being at least partially transported toward the enclosure **14** through the line **234** and the valve **236**.

Hot air can also be provided to balance the temperature. This hot air is taken directly in the propulsion engine **16**A of the aircraft and is conveyed toward the enclosure **14** through the hot air intake line **238** and the control valve **240**.

A fourth aircraft **250** according to the invention is illustrated by FIG. **13**.

Unlike the second aircraft **210** according to the invention, the rotary assembly **40** does not have an auxiliary compressor.

The production assembly **22** comprises an intermediate compression module **252** comprising an auxiliary compressor **212** driven independently by an engine **254** mechanically independent of the power turbine **52** and the rotation of the shaft **50**.

The auxiliary engine **254** is for example an electric motor rotated by means of electricity supplied by the electric network **20** of the aircraft **250**. Alternatively, the engine **254** is supplied with a combustion gas from the combustion chamber **80**.

As previously described, the transport line **96** includes an upstream section **214** extending between the outlet of the main compressor **54** and the inlet of the auxiliary compressor **212** and a downstream section **216** extending between the outlet of the auxiliary compressor **212** and the inlet of the cold turbine **56**.

In one advantageous alternative, a bypass line **256** of the auxiliary compressor **212** is provided with a bypass valve **258** and connects a point upstream of the auxiliary compressor **212** to a point situated downstream of the auxiliary compressor **212**.

The operation of the fourth aircraft **250** differs from the operation of the second aircraft **210** in that electricity is supplied to the engine **254** by the electric network **20** to rotate the auxiliary compressor **212** when the main compressor **54** is rotated by the shaft **50** under the effect of the rotation of the power turbine **52**.

Alternatively, the compressor **54** is partially supplied by a gas current coming from a propulsion engine **16**A, **16**B, in addition to the supply of outside air from the upstream assembly **42**.

Owing to the described invention, it is therefore possible to have an autonomous electricity production and conditioning system **22**, which has a compact structure. The autonomous system **22** guarantees complete independence between the thermodynamic operation of the propulsion engine(s) **16**A, **16**B of the aircraft, the electricity production necessary for the services of the aircraft, and the conditioning of the gas present in the enclosure **14** of the aircraft.

Such an arrangement significantly reduces the weight and bulk of the aircraft, while ensuring minimum fuel consumption.

The presence of a fuel storage device **18** according to the invention provided with an auxiliary reservoir containing a second batch of fuel separate from the first batch of fuel present in the main reservoir **130**A, **130**B guarantees an absence of contamination and a potential energy source for the aircraft, in particular when the engines **16**A, **16**B of the aircraft are not capable of propelling it and creating enough electricity.

When the device **18** is used in combination with an auxiliary alternator **60** that is not used under normal flight conditions, but which is tested at the beginning of each flight, the aircraft has an autonomous system **22** capable of particularly safely producing backup electricity offsetting a major failure of the propulsion engine(s) **16**A, **16**B as described in the main electricity production loss mode illustrated by FIG. **8**. Such a system could replace a traditional backup energy production device of the Run Air Turbine type. This system **22** is significantly more reliable relative to a RAT system comprising a wind turbine.

In one alternative illustrated in FIG. **14**, the upstream air supply assembly **42** comprises an auxiliary supply bleed **70**D for circulating outside air toward the upstream heat exchanger **72**. The auxiliary supply bleed **70**D is tapped upstream of the upstream heat exchanger **72** on the upstream line **74**. It passes through the upstream heat exchanger **72**. It comprises, upstream or downstream of the upstream heat exchanger **72**, a movable outside air driving member, such as a propeller **70**E. The propeller **70**E is electrically powered by the electric network of the airplane **20**.

This arrangement supplies a sufficient quantity of outside air circulating through the exchanger **72**, in particular when the aircraft **10** is stopped, or on the ground.

In this arrangement, an additional bypass line **70**F can be provided on the line **74**, to go around the heat exchanger **72** and supply the compressor **54** directly.

In alternatives, the system **22** does not have a line **76**, a line **102**, a line **105**, or a return bleed **220**. It may also be provided without an auxiliary assembly **116**.

"Line" generally refers, within the meaning of the present invention, to any hollow element capable of transporting a fluid between two points, and not necessarily a tubular element.

The invention claimed is:

1. An autonomous electricity production and conditioning system for an aircraft, including:

a rotary shaft;

a main compressor mounted integral with the rotary shaft;

a power turbine for rotating the rotary shaft; and

a cold expansion turbine rotated by the rotary shaft and supplied with a compressed gas from the main compressor;

wherein the system comprises an upstream assembly supplying outside air to the aircraft, which outside air has not passed through a propulsion engine of the aircraft, the upstream assembly being connected to an inlet of the main compressor, the system also including a main alternator mechanically connected to the rotary shaft, and an auxiliary alternator separate from the main alternator, and wherein the auxiliary alternator is mechanically connected to the rotary shaft; and

an electric network of the aircraft includes batteries which are electrically connectable to the auxiliary alternator to supply the auxiliary alternator with power and cause it to operate as an engine to start rotation of the rotary shaft and electrically disconnectable from the auxiliary alternator when the power turbine rotates the rotary shaft independently, such that when the rotary shaft is rotated by the power turbine, the main alternator operates as a generator and provides electric power to the electric network of the aircraft.

2. The system according to claim **1**, wherein the supply assembly includes an upstream heat exchanger for placing the air outside the aircraft, not having passed through a propulsion engine of the aircraft, in a heat exchange relationship with at least part of the compressed gas from the main compressor.

3. The system according to claim **1**, including a downstream heat exchanger, a condenser, and a separator that receive at least part of the compressed gas from the main compressor, to produce a compressed gas to be introduced into the cold turbine, the condenser placing a cooled expanded gas from the cold turbine in heat exchange with a compressed gas from the downstream heat exchanger.

4. The system according to claim **1**, including at least one gas distribution hose for conducting an expanded gas from the cold turbine toward an enclosure of the aircraft to be conditioned.

5. An aircraft, comprising a system according to claim **1** and a fuel storage device,

the fuel storage device comprising:

at least one main reservoir to contain a first batch of fuel;

at least one feed line for supplying a propulsion engine of the aircraft with the first batch of fuel contained in the at least one main reservoir; and

at least one auxiliary reservoir to contain a second batch of fuel separate from the first batch of fuel, the auxiliary reservoir being connected to the at least one main reservoir, the storage device including an intake line for bringing the second batch of fuel contained in the at least one auxiliary reservoir toward a combustion chamber of the aircraft independent of any engine of the aircraft.

6. The system according to claim **1**, including a combustion chamber, independent of any propulsion engine of the aircraft, the system including a channel for supplying the power turbine with at least one combustion gas from the combustion chamber.

7. The system of claim **6** including:

at least one fuel reservoir to contain a first batch of fuel to supply the propulsion engine for propulsion of the aircraft; and

means for conveying fuel from the at least one fuel reservoir to the combustion chamber.

8. The system according to claim **6**, including a withdrawal hose for withdrawing a compressed gas from the main compressor emerging in the combustion chamber.

9. The system according to claim **8**, including an auxiliary compressor arranged downstream of the main compressor and upstream of the cold turbine to receive at least part of the compressed gas from the main compressor, the withdrawal hose being tapped between the main compressor and the auxiliary compressor upstream of the auxiliary compressor.

10. The system according to claim **9**, wherein the auxiliary compressor is rotated by the rotary shaft.

11. The system according to claim **1**, including an auxiliary compressor positioned away from the rotary shaft, the system including an auxiliary motor for rotating the auxiliary compressor.

12. The system of claim **11** wherein the auxiliary motor is an electric motor rotated by electricity supplied by the electrical network of the aircraft.

13. The system according to claim **1**, including a member for transmitting the rotating movement of the rotary shaft mechanically connected to the rotary shaft.

14. The system of claim **13** wherein the member for transmitting rotating movement to the rotary shaft is a speed reducer.

15. A method for conditioning an aircraft, including the following steps:

providing the autonomous system according to claim **1**;

activating the power turbine to rotate the rotary shaft;

jointly rotating the main compressor and the expansion turbine; and

supplying the main compressor with air outside the aircraft not having passed through a propulsion engine of the aircraft; and

the method including a starting step in which the batteries of the electric network of the aircraft are electrically connected to the auxiliary alternator to supply the auxiliary alternator and cause it to operate as an engine, then deactivating the auxiliary alternator by disconnecting the batteries from the auxiliary alternator when the power turbine rotates the shaft independently, such that when the rotary shaft is rotated, the main alternator operates as a generator and provides electric power to the electric network of the aircraft.

16. The method according to claim **15**, including the following steps:

activating a combustion chamber of the aircraft to produce a combustion gas;

supplying the power turbine with the combustion gas; and

withdrawing at least part of the compressed gas from the main compressor to supply the combustion chamber.

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